University of Warsaw
Faculty of Economic Sciences

Monetary policy implementation

Advanced Macroeconomics: Lecture 10

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Conventional monetary policy

Choice of policy instrument

Based on Poole (1970)

Central bank can control:

- Money supply (monetary base)
- Nominal interest rate

The other variable is then determined endogenously

Central bank cannot observe shocks in real time, but only with a certain lag

Central bank sets policy for a given period before shocks occur

In a very short period of time we can ignore price changes

Poole's analysis

Normalizing and simplifying assumptions: $p_t = 0$, $\mathrm{E}y_{t+1} = 0$, $\mathrm{E}\pi_{t+1} = 0$, $\rho = 0$

NKIS curve

$$y_t = -\alpha i_t + u_t$$

Aggregate demand shock u_t has variance σ_u^2

Money demand curve

$$m_t = y_t - \omega i_t + v_t$$

Money demand shock v_t has variance σ_v^2

Both shocks are drawn independently

Central bank aims to minimize variance in output $\mathrm{E}\left[y_t\right]^2$

Money supply control

Solving the system by eliminating i_t we get

$$y_t = \frac{\alpha m_t + \omega u_t - \alpha v_t}{\alpha + \omega}$$

Setting m_t such that $\mathrm{E}\left[y_t\right] = 0$ we get

$$y_t = \frac{\omega u_t - \alpha v_t}{\alpha + \omega}$$

The variance of output is then

$$\mathrm{E}\left[y_t\right]^2 = \frac{\omega^2 \sigma_u^2 + \alpha^2 \sigma_v^2}{\left(\alpha + \omega\right)^2}$$

Interest rate control

We just need the NKIS curve

Setting i_t such that $\mathrm{E}[y_t] = 0$ we get

$$y_t = u_t$$

The variance of output is then

$$\mathrm{E}[y_t]^2 = \sigma_u^2$$

Interest rate control is preferred if

$$\sigma_v^2 > \left(1 + \frac{2\omega}{\alpha}\right)\sigma_u^2$$

Choice of policy instrument

Interest rate control is preferred if

- Money demand variance is high
- Aggregate demand variance is low
- Elasticity of money demand with respect to interest rate is low
- Elasticity of aggregate demand with respect to interest rate is high

Money supply control was employed successfully for many years at the central banks of e.g. Germany and Switzerland

Nowadays it is still popular in countries with underdeveloped financial markets

Creation of money and credit

In reality the central bank exerts direct control only over the monetary base, and not money supply

Majority of money supply is created by commercial banks who grant credit / loans

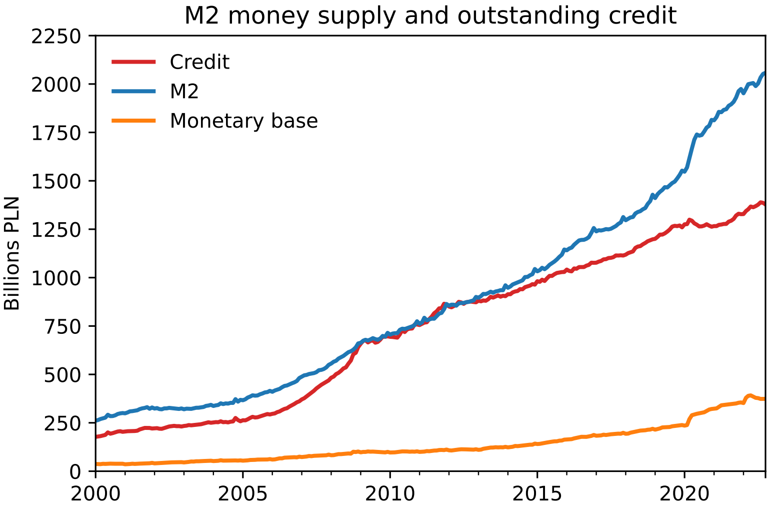
Credit (and money) are created when:

1. There is demand for credit
2. Banks want to grant credit (deem applicants creditworthy)
3. Banks have sources of financing and capital

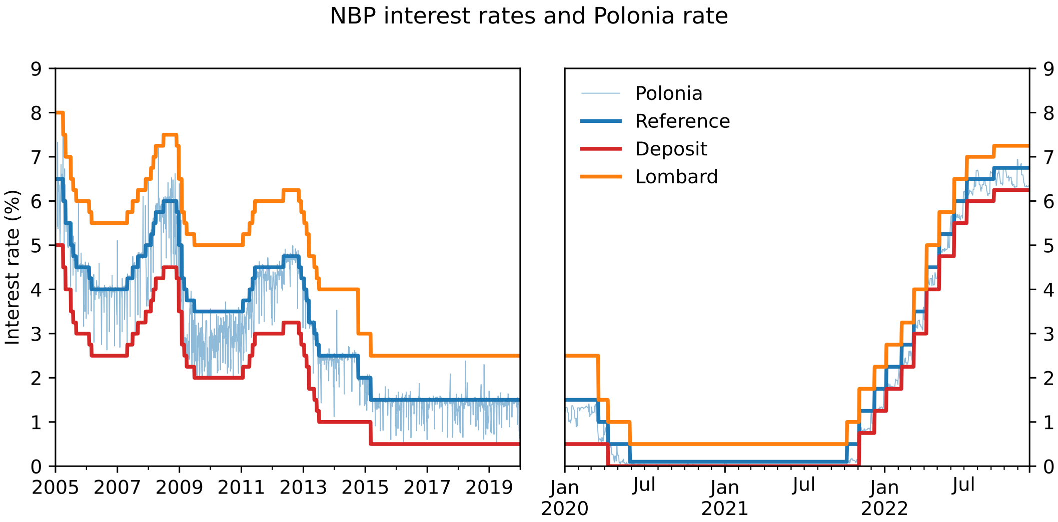
Financing is not necessary at the moment of granting a loan, but banks need to observe reserve requirements

This creates demand for time deposits and Central bank reserves

Money creation ≈ credit creation



Interest rate control: interbank market



Interest rate control: interbank market

The central bank wants to steer the interbank market to make overnight transactions at the central bank's main interest rate [ECB: MRO]

Upper and lower bounds for interbank interest rates:

- Any commercial bank can borrow reserves from the central bank at the discount rate [ECB: marginal lending rate]
- Any commercial bank can deposit reserves at the central bank at the rate on excess reserves [ECB: deposit rate]

Central bank performs open market operations, buying and selling assets for reserves, affecting the interbank market rates

Central bank can directly affect only the very short term interest rates!

Short- and long-term interest rates

Monetary policy affects long-term interest rates via expectations on future interest rates

No-arbitrage conditions (omitting various premia)

- Two-period contract

$$i_{t+2} \approx \frac{i_t + i^e_{t+1}}{2}$$

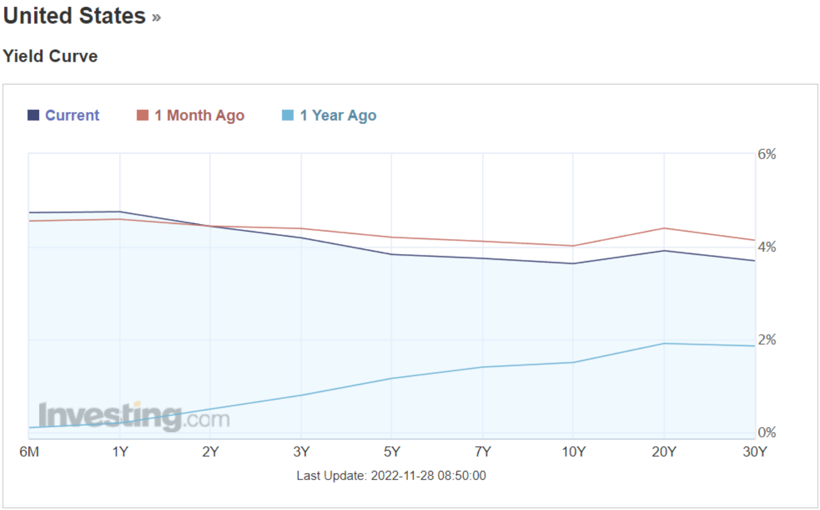
- n-period contract

$$i_{t+n} \approx \frac{i_t + \sum_{s=1}^{n-1} i^e_{t+s}}{n}$$

Usually long-term interest rates are higher than short-term (liquidity premium, risk premium, etc.)

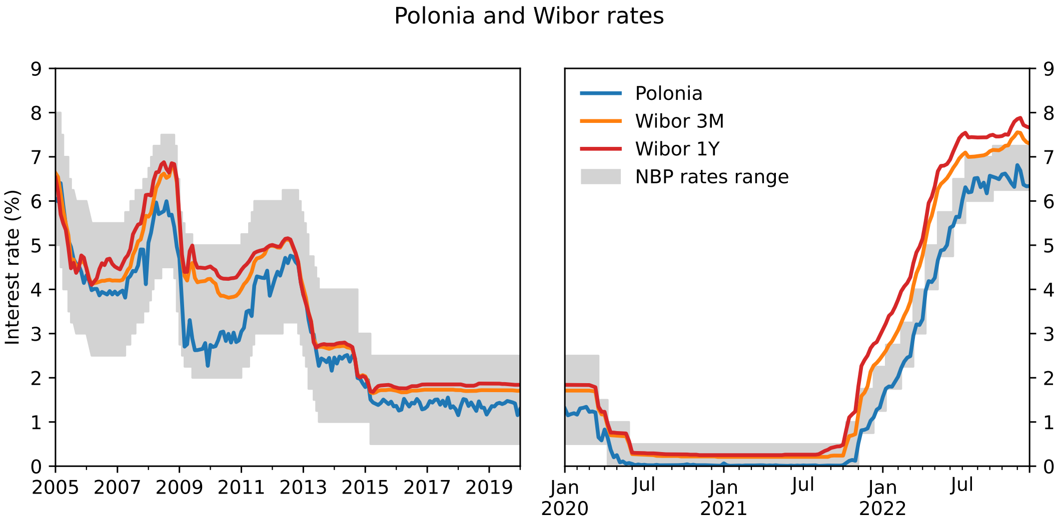
Yield curve inversion (short-term rates higher than long-term) signals expectations of monetary policy easing in the future

Inverted yield curve in the USA



Investing.com

Short- and long-term interest rates



Interest rates on deposits and loans

Interbank market interest rates determine the “cost” of granting a credit / loan

Commercial banks are almost indifferent between financing loans from central bank reserves or time deposits

Interest on deposits $\approx$ interbank market rate

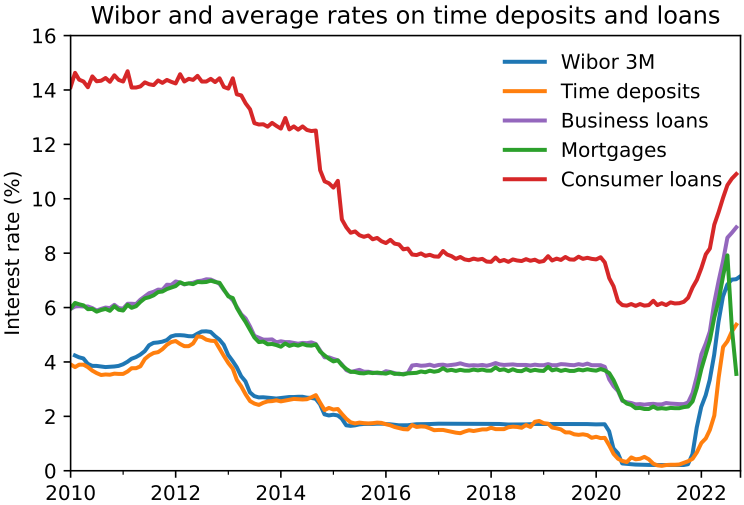
Interest on loans $>$ interbank market rate

Reasons for the above:

1. Banks’ market power
2. Monitoring costs
3. Credit risk premium

Interest on non-collateralized loans is higher than on collateralized (mortgages and business loans)

Interest rates on deposits and loans



Monetary transmission mechanism

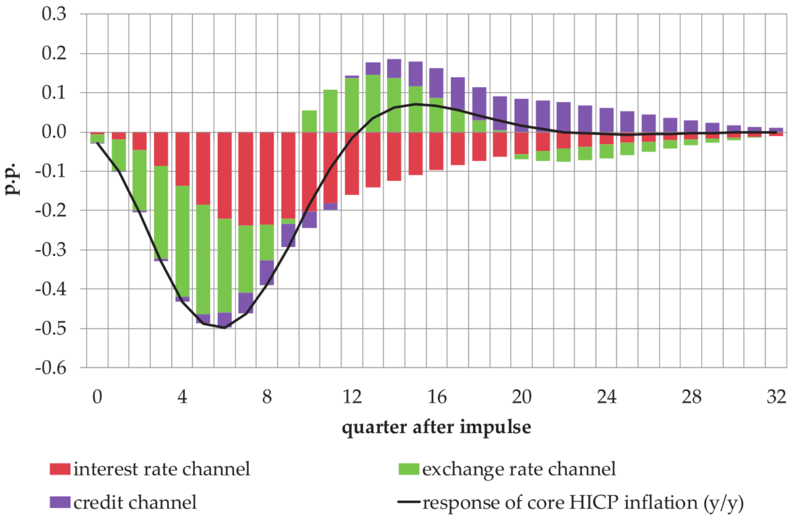
Channels of monetary policy transmission

In the simplest New Keynesian model monetary policy affects works through affecting the intertemporal consumption choice in response to real interest rate changes

In reality other channels are also operational:

1. Interest rate channel
    - Direct effect (including changes in disposable income)
    - Asset price changes
2. Exchange rate channel
3. Expectations channel
4. Credit channel

Relative importance of channels in Poland



Chmielewski et al. (2018)

Interest rates and asset valuation

Simplify: nominal interest rate is constant over time

Pricing bonds

$$P_B = \frac{C_1}{1+i} + \frac{C_2}{(1+i)^2} + \ldots + \frac{C_{T-1}}{(1+i)^{T-1}} + \frac{C_T + F}{(1+i)^T}$$

where C is coupon payment and F is face value

Pricing stocks (fundamental)

$$P_S = \frac{D_1}{1+i} + \frac{D_2}{(1+i)^2} + \frac{D_3}{(1+i)^3} + \ldots$$

$$P_S = \frac{D_0(1+g)}{1+i} + \frac{D_0(1+g)^2}{(1+i)^2} + \frac{D_0(1+g)^3}{(1+i)^3} + \ldots \approx \frac{D_0}{i-g}$$

where D is nominal dividend growing at rate g

Interest rates and asset valuation

Pricing stocks (fundamental)

$$P_S \approx \frac{D_0}{i - g}$$

Lower interest rates reduce the discounting and asset valuation goes up (direct effect)

Lower interest rates induce output gap and inflation to increase, translating to higher g (indirect effect)

A similar formula can be applied to valuate housing, where D_0 would be the (hypothetical) nominal rental cost and g its growth rate

Response of stock prices to increases in interest rates

Table 5: Regressions of dividend adjusted nominal stock returns against the change in the short-term interest rate.

Country	α	β	F	JB	R^2
Belgium	0.835 ***	-1.574 ***	13.83 ***	235.86 ***	0.037
Canada	0.824 ***	-1.62 ***	16.07 ***	421.91 ***	0.043
Finland	0.925	-4.07 *	2.23	8.01 ***	0.007
France	1.034 ***	-2.458 ***	15.59 ***	15.41 ***	0.042
Germany	0.637 ***	-1.474 *	4.75 **	121.19 ***	0.013
Italy	0.941 ***	-1.5 ***	7.77 ***	36.08 ***	0.022
Japan	0.388	-1.889	2.40	33.86 ***	0.006
Netherlands	0.976 ***	-0.705 **	2.94 *	198.99 ***	0.008
Spain	0.87 **	-0.078	0.006	219.67 ***	0.000
Sweden	1.501 ***	-1.87 **	2.89 *	44.87 ***	0.014
Switzerland	0.69 ***	-0.343 *	1.65	392.83 ***	0.004
United Kingdom	1.075 ***	-2.29 ***	27.49 ***	1364.29 ***	0.072
United States	0.869 ***	-0.844 **	4.261 **	171.41 ***	0.011

Note:

(a) OLS estimates, with Newey-West heteroskedasticity and serial correlation consistent covariance matrix estimator, of the regression equation $\Delta S_t^D = \alpha + \beta \Delta i_t + u_t$ where ΔS_t^D is the monthly dividend adjusted nominal stock return and Δi_t is the change in the short-term interest rate. The Datastream return series are available from 1973.02 for Belgium, Canada, France, German, Italy, Japan, Netherlands, Switzerland, UK, and US, and 1982.02, 1987.04 and 1988.05 for Sweden, Spain, and Finland, respectively.

Ioannidis and Kontonikas (2006)

Asset valuation and consumption choice

Two-period utility maximization problem

$$\begin{aligned} \max \quad & U = \ln C_t + \beta \ln C_{t+1} \\ \text{subject to} \quad & C_t + \frac{A_{t+1}}{1+r} = Y_t + A_t \\ & C_{t+1} = Y_{t+1} + A_{t+1} \end{aligned}$$

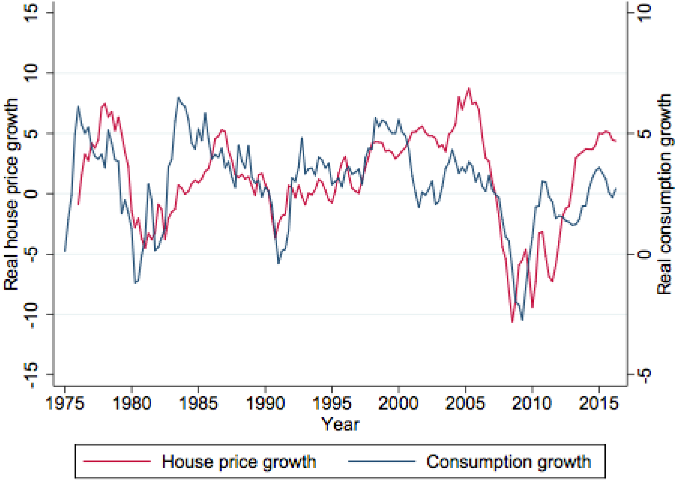
where A_t is the value of assets at beginning of period t

Optimal consumption choice in t

$$C_t = \frac{1}{1+\beta} \left[A_t + Y_t + \frac{Y_{t+1}}{1+r} \right]$$

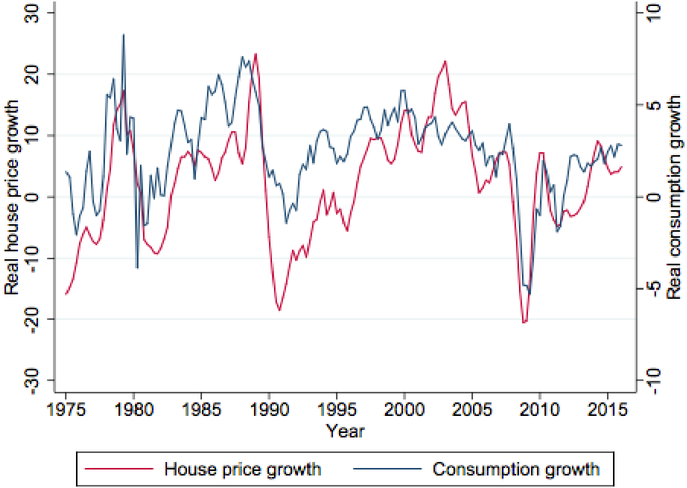
Higher asset valuation encourages higher consumption

House price growth vs consumption growth: USA



Cloyne et al. (2017)

House price growth vs consumption growth: UK



Cloyne et al. (2017)

Households with mortgage react the strongest to i

Cloyne, Ferrero and Surico (2016)

Neoclassical investment theory

Two-period firm value maximization problem

$$\max_{I_t,\, K_{t+1}} \quad V_t = F\left(K_t\right) - I_t + \frac{1}{1+r}\left[F\left(K_{t+1}\right) + \left(1-\delta\right) K_{t+1}\right]$$
$$\text{s. t.} \quad K_{t+1} = I_t + \left(1-\delta\right) K_t$$

Lagrangian

$$\mathcal{L} = F\left(K_t\right) - I_t + \frac{1}{1+r}\left[F\left(K_{t+1}\right) + \left(1-\delta\right) K_{t+1}\right] + q\left[I_t + \left(1-\delta\right) K_t - K_{t+1}\right]$$

First order conditions

$$\frac{\partial \mathcal{L}}{\partial I_t} = -1 + q = 0$$
$$\frac{\partial \mathcal{L}}{\partial K_{t+1}} = -q + \frac{F_K\left(K_{t+1}\right) + \left(1-\delta\right)}{1+r} = 0$$

Neoclassical investment theory

Simplifying

$$q = 1$$
$$F_K\left(K_{t+1}\right) = \left(1 + r\right) q - \left(1 - \delta\right)$$

Solution

$$F_K\left(K_{t+1}\right) - \delta = r$$

Marginal product of capital (net, after depreciation) is equal to the real interest rate

In response to the change in the interest rates it is optimal to instantaneously adjust the capital stock

Model predicts very strong reaction of investment

Capital installation costs

Investment requires additional installation costs equal to $\frac{\phi}{2}\frac{I_t}{K_t}$ per unit of investment

$$\begin{aligned} \max_{I_t,\, K_{t+1}} \quad & V_t = F\left(K_t\right) - \left(1 + \frac{\phi}{2}\frac{I_t}{K_t}\right) I_t \\ & \quad + \frac{1}{1+r}\left[F\left(K_{t+1}\right) + \left(1-\delta\right) K_{t+1}\right] \\ \text{s.t.} \quad & K_{t+1} = I_t + \left(1-\delta\right) K_t \end{aligned}$$

Lagrangian

$$\begin{aligned} \mathcal{L} = & F\left(K_t\right) - I_t - \frac{\phi}{2}\frac{I_t^2}{K_t} + \frac{1}{1+r}\left[F\left(K_{t+1}\right) + \left(1-\delta\right) K_{t+1}\right] \\ & + q\left[I_t + \left(1-\delta\right) K_t - K_{t+1}\right] \end{aligned}$$

Capital installation costs

First order condition

$$\frac{\partial \mathcal{L}}{\partial I_t} = -1 - \phi \frac{I_t}{K_t} + q = 0$$

Simplifying

$$q = 1 + \phi \frac{I_t}{K_t} \quad \leftrightarrow \quad I_t = \frac{q-1}{\phi} K_t$$

Investments are made if $q > 1$

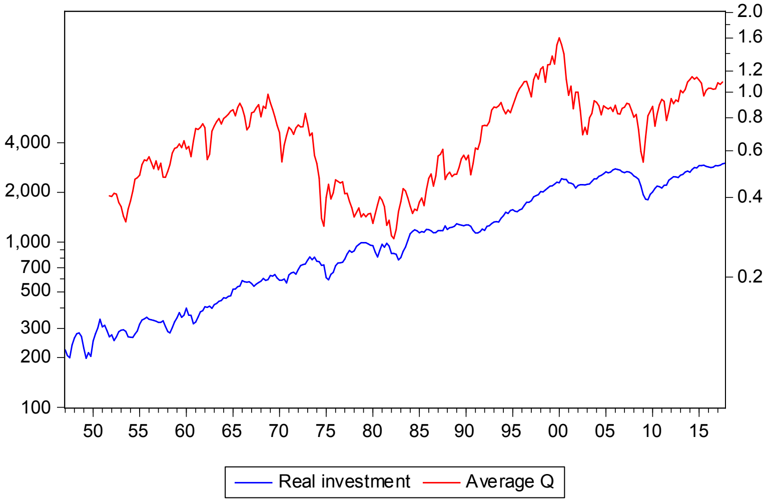
It can be shown (under certain assumptions) that

$$q \approx Q \equiv \hat{V}_t / K_t$$

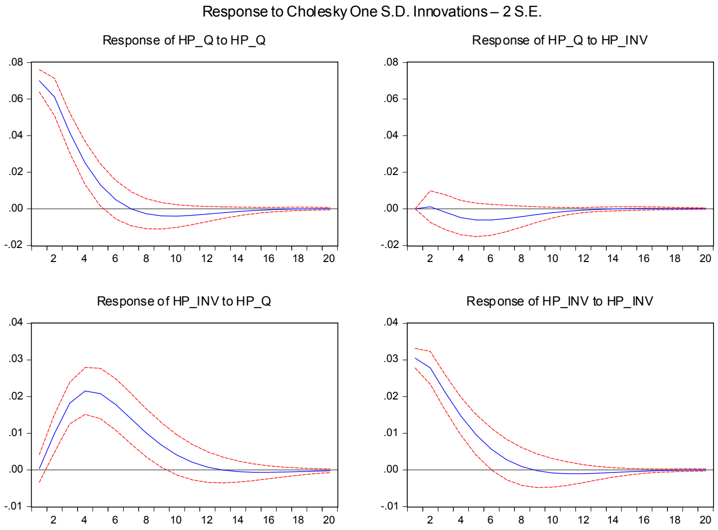
where $\hat{V}_t$ is the current market value of the firm

Firms invest more eagerly if their market valuation grows

Investment and Q: USA



Investment and Q: USA



Exchange rate channel: interest rate parity

Interest rates in any two countries should be equal, controlling for expected exchange rate movements and risk premium ϱ

$$i_t = i_t^F + \frac{S_{t+1}^e - S_t}{S_t} + \varrho_t$$

Expected exchange rate movement can be expressed as

$$\Delta s_{t+1}^e = \left(i_t - i_t^F\right) - \varrho_t$$

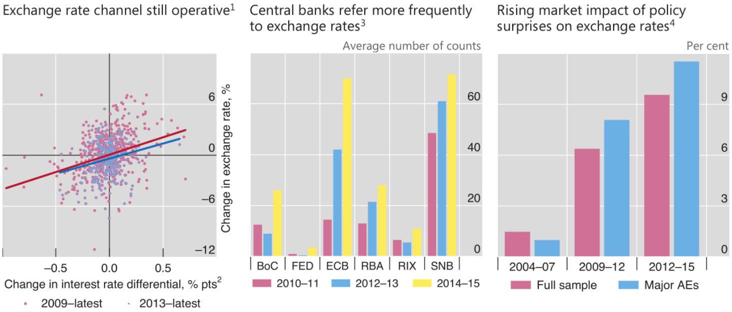
Econometric model

$$\Delta s_{t+1} = \alpha + \beta\left(i_t - i_t^F\right) + \varepsilon_t$$

Changes in exchange rates vs changes in interest rates

External channels of monetary policy appear to grow in importance

Graph IV.8



BoC = Bank of Canada; FED = Federal Reserve; ECB = European Central Bank; RBA = Reserve Bank of Australia; RIX = Sveriges Riksbank; SNB = Swiss National Bank.

[1] For eight advanced economies. [2] Changes in the interest rate differential between two-year domestic and US government bonds. [3] In monetary policy statements and press conferences. [4] Changes of bilateral US dollar exchange rates over the 30-minute window around the timing of monetary policy announcements, per 1 percentage point increase in two-year bond yields. Full sample consists of seven advanced economies.

Sources: M Ferrari, J Kearns and A Schrimpf, "Monetary policy and the exchange rate", BIS, mimeo, 2016; national data; BIS calculations.

BIS (2016)

Exchange rate and inflation

Exchange rate depreciation puts upward pressure on inflation

- Increases prices of imported goods (in terms of domestic currency)
- Increases aggregate demand through higher net exports

Impact of depreciation on prices and net exports is limited

- Exporters set prices in importers' currencies (pricing to market)
- Global value chains: export / import depend on contracts within the value chain, higher profitability from exporting is balanced by higher prices of imported inputs

Partial exchange rate pass-through in Central Europe

Table 7 Summary of ERPT Estimates

Country	Response of HICP to 1% NEER Shock				Cointegration
	6 months	*12 months*	*24 months*	*48 months*	*Long-Run*
Bulgaria	0.203	0.213	0.320	0.360	0.698
Czech Republic	0.246	0.384	0.414	0.434	0.505
Estonia	0.060	0.159	0.572	0.598	0.925
Hungary	0.089	0.239	0.367	0.396	0.634
Latvia	0.356	0.439	0.509	0.619	0.969
Lithuania	0.147	0.211	0.335	0.460	0.440
Poland	0.267	0.360	0.397	0.400	0.469
Romania	0.135	0.177	0.230	0.340	0.436
Slovakia	0.046	0.176	0.389	0.391	0.370

Beirne and Bijsterbosch (2016)

Expectations channel

Under nominal rigidities inflation expectations affect

- Nominal wage negotiations
- Price setting by firms

Management of expectations allows the CB to influence wages and prices without actively changing interest rates

Monetary policy can affect inflation more efficiently and with lesser side effects (lower output gap volatility)

BC can manage expectations by e.g.

- Announcing the inflation target (anchoring)
- Publishing inflation report, minutes (communicating on monetary policymaking, increasing CB credibility)
- Publishing forecasts (as above + highlighting uncertainty)

Credit channel: LP curve

Lending rate depends on the bank's assessment of the repayment probability (q)

The lending rate depends also on the opportunity cost (e.g. the government bonds yield)

Bank's preferences are described by the LP curve

$$q\,(1+r) = 1 + r^{risk-free}$$

Above equation assumes risk neutrality, but:

1. Banks are risk averse
2. Small banks are at a disadvantage relative to larger lenders in finding funds to lend and may charge higher interest rates

Credit channel: BC curve

Probability of repayment depends on the interest rate due to adverse selection

Consider two types of borrowers: G and B, $q_G > q_B$

Under perfect information

$$(1 + r_G)\, q_G = (1 + r_B)\, q_B = 1 + r^{risk-free}$$

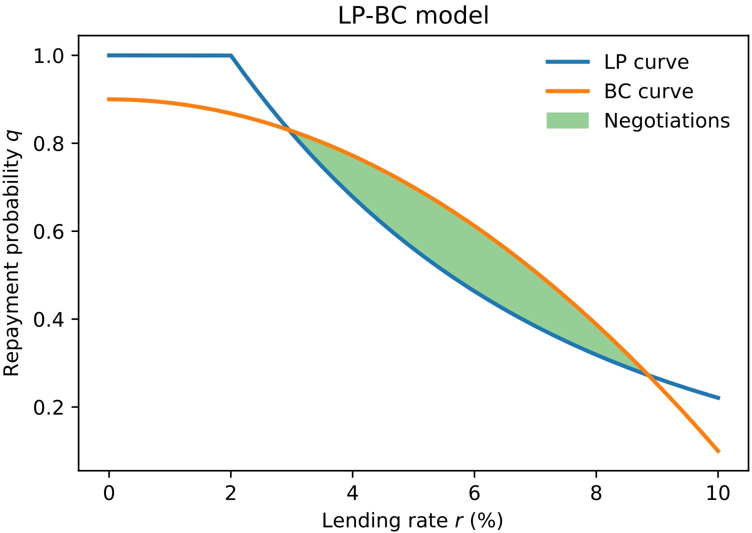
Under imperfect information it is not possible to fully differentiate the lending rate with respect to borrowers' types

If fraction g of borrowers is of type G then

$$(1 + r)\, g\, q_G + (1 + r)\, (1 - g)\, q_B = 1 + r^{risk-free}$$

But higher interest rates discourage borrowers with high repayment probability ($\partial g / \partial r < 0$)

LP-BC model


LP-BC model
LP curve
BC curve
Negotiations
Repayment probability q
1.0
0.8
0.6
0.4
0.2
0
2
4
6
8
10
Lending rate r (%)

Credit channel: monetary policy

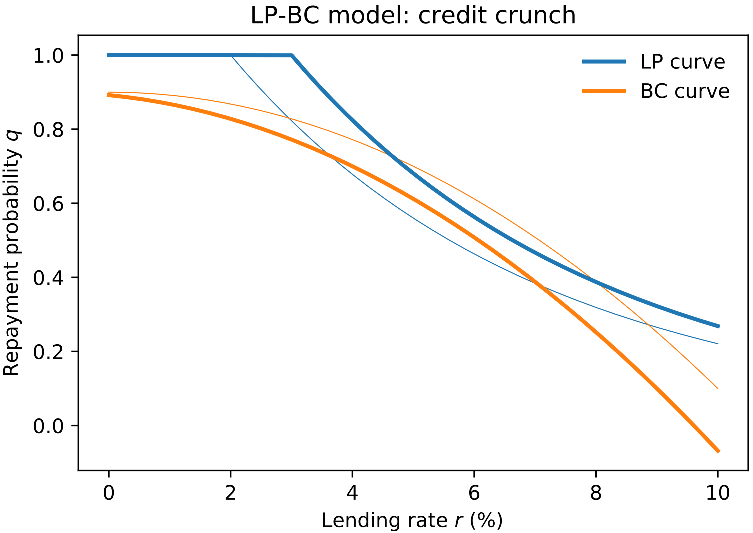
In equilibrium banks may be less willing to extend credit at each level of interest rate

Contractionary monetary policy (increase in the interest rate) has two effects:

1. Increases the risk-free interest rate and the difficulty in obtaining loanable funds by smaller lenders
2. Reduces the value of assets, increases debt-service requirements on previously issued debt, reduces the present value of future cash receipts

BC curve shifts leftwards, LP rightwards

LP-BC model: credit crunch



Monetary policy transmission

Central banks cannot perfectly control money supply and all interest rates

The effects of monetary policy depend on the behavior of commercial banks

- Interest rates on deposits and loans may differ from the CB main interest rate
- Willingness of commercial banks to extend credit affects the effectiveness of CB's monetary policy

Monetary policy at the Effective Lower Bound

Liquidity trap

In response to the 2007-2008 financial crisis many central banks have cut interest rates to around 0%

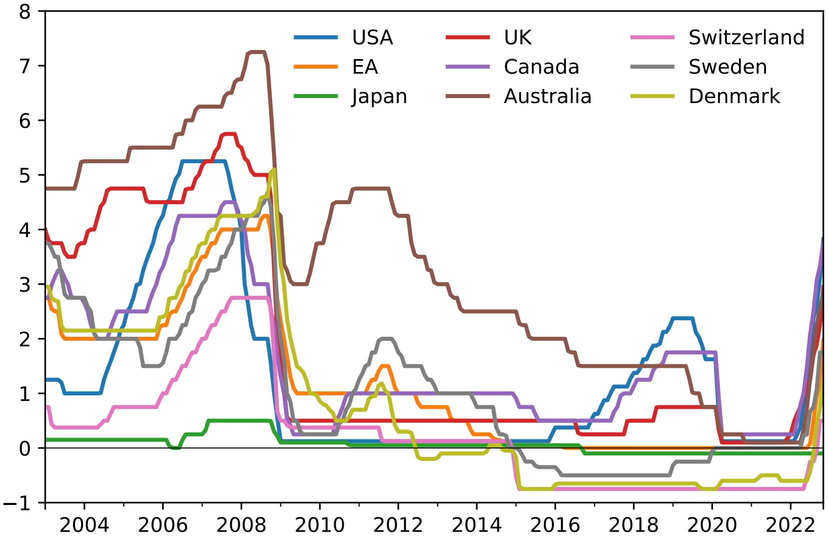
But the desired level of interest rates was then negative

Since 2012 more and more central banks have set negative interest rates

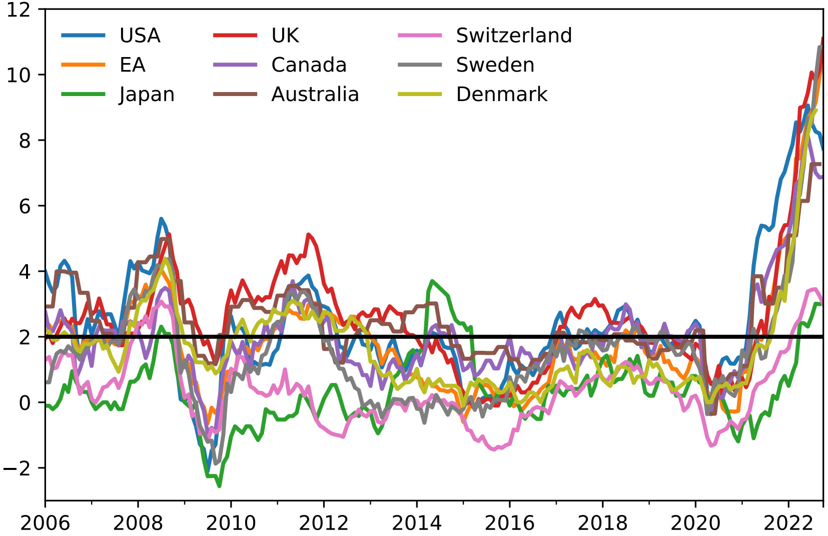
These events raise several questions:

- Why (and where) is the Effective Lower Bound (ELB)
- How to conduct monetary policy in a liquidity trap
- What is then the optimal inflation target

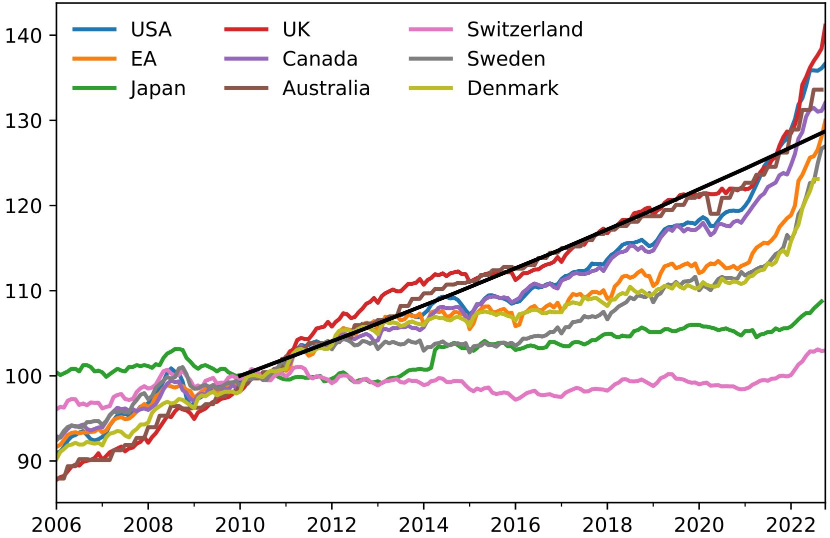
Nominal interest rates in advanced economies



Inflation rates (year over year) in advanced economies



Price level in advanced economies



Zero / Effective Lower Bound (ZLB / ELB)

Intuition: lower bound for nominal interest rates is 0%

The nominal rate of return from cash is 0%

Households are not willing to hold assets that yield negative nominal return, prefer cash

In reality the ELB is not at 0, since there are costs of storing and securing cash

Ideas to eliminate the ZLB / ELB (Buiter 2009):

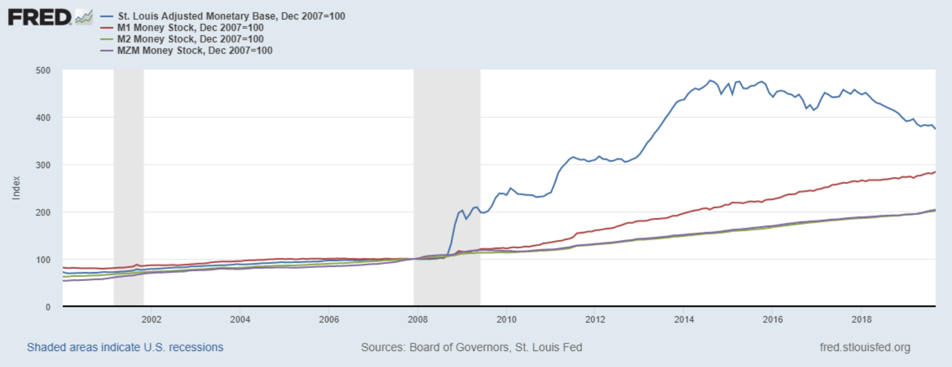
- Abandon cash (100% electronic money)
- Tax cash (need to extend its validity)
- Floating exchange rate between cash and electronic money

General public vehemently opposes these ideas

Monetary policy at the ELB

Reducing the nominal interest rate no longer available

Expansion in monetary base (accomodating higher demand for reserves) does not translate to increases in money supply aggregates



Federal Reserve Economic Database

Monetary policy at the ELB

What works then?

- Forward guidance: central bank manages expectations on future nominal interest rates to indirectly affect long-term interest rates
- Quantitative easing: central bank purchases certain assets to directly affect long-term interest rates

Both implemented in practice

Forward guidance

CB promises to maintain rates "lower for longer" than would be indicated by the monetary policy rule

Raises inflation expectations

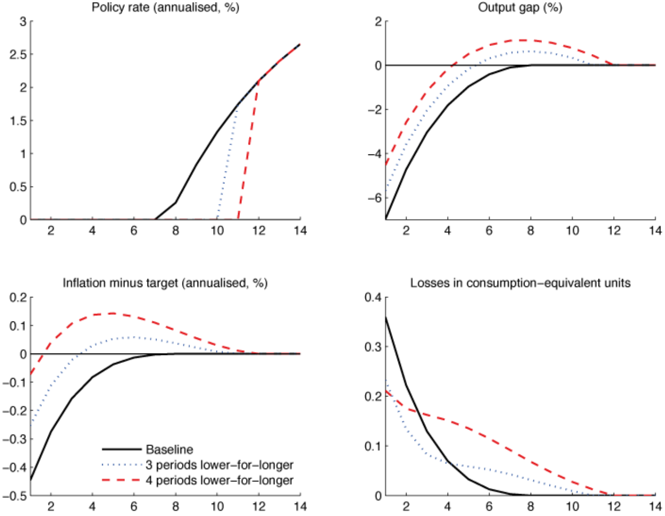
Reduces expected real interest rates

Expansionary effect on the economy

To support continued progress toward maximum employment and price stability, the Committee expects that a highly accommodative stance of monetary policy will remain appropriate for a considerable time after the economic recovery strengthens. In particular, the Committee also decided today to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that exceptionally low levels for the federal funds rate are likely to be warranted at least through mid-2015.

US FOMC (2012)

Effects of forward guidance in the New Keynesian model



Harrison et al. (2017)

Quantitative easing

Purchasing assets of longer maturities

Reduces rate of return on those assets

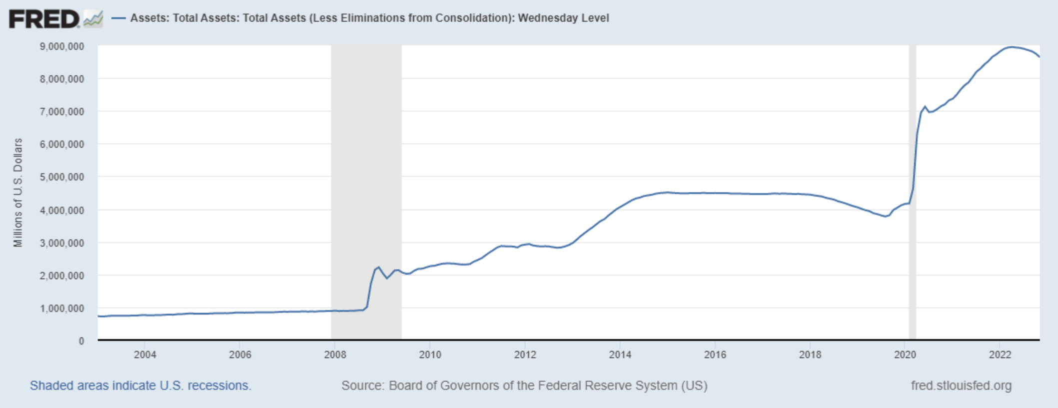
Reduces expected real interest rates

Expansionary effect on the economy

To support a stronger economic recovery and to help ensure that inflation, over time, is at the rate most consistent with its dual mandate, the Committee will continue purchasing additional agency mortgage-backed securities at a pace of $40 billion per month. The Committee also will continue through the end of the year its program to extend the average maturity of its holdings of Treasury securities, and it is maintaining its existing policy of reinvesting principal payments from its holdings of agency debt and agency mortgage-backed securities in agency mortgage-backed securities. These actions, which together will increase the Committee's holdings of longer-term securities by about $85 billion each month through the end of the year, should put downward pressure on longer-term interest rates, support mortgage markets, and help to make broader financial conditions more accommodative.

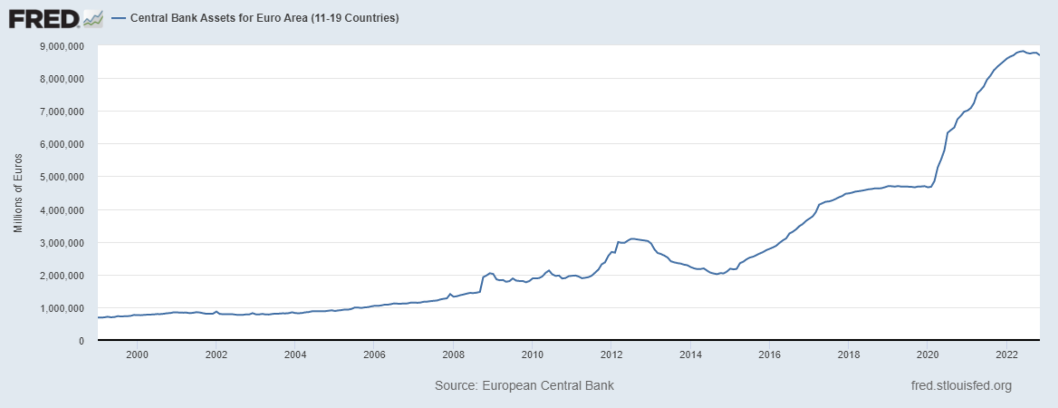
US FOMC (2012)

Quantitative easing: balance sheet of Fed



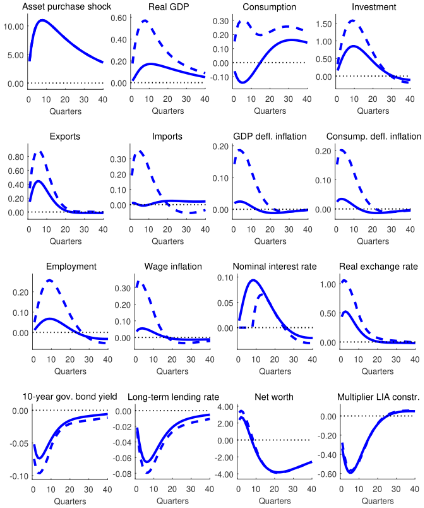
Federal Reserve Bank of St. Louis

Quantitative easing: balance sheet of ECB



Federal Reserve Bank of St. Louis

Effects of quantitative easing (+FG) in the EBC's model



Coenen et al. (2018), Figure 14

Limits to effectiveness of unconventional policies

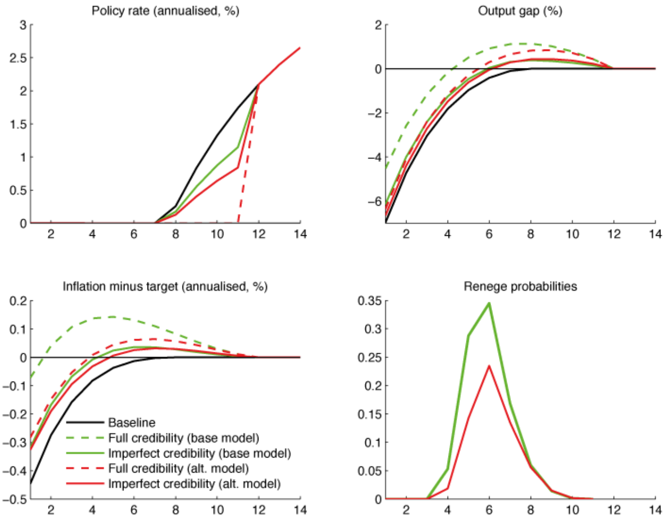
In the New Keynesian model forward guidance works “too well” (Del Negro et al. 2015)

In reality effectiveness of these policies depends on frictions and imperfections in the financial markets

Information frictions: private agents have less than perfect information on future monetary policy (Harrison et al. (2017), Campbell et al. 2019)

Market frictions: imperfect degrees of substitutability between different classes of assets (Haldane et al. 2016)

Forward guidance under imperfect central bank credibility



Harrison et al. (2017)

Four-equation New Keynesian model

Based on Friedman (2013)

Loan contracts have maturity longer that 1 period

Interest rates that households and businesses face are determined by the commercial banks, central bank affects them only indirectly

Simple modification of the three-equation mode:

$$
\begin{aligned}
\text{NKPC} \qquad & \pi_t = \beta \mathrm{E}_t \pi_{t+1} + \kappa x_t + e_t \\
\text{NKIS} \qquad & x_t = \mathrm{E}_t x_{t+1} - \frac{1}{\sigma} \left(i_t^p - \mathrm{E}_t \pi_{t+} - \rho \right) + u_t \\
\text{Taylor rule} \qquad & i_t = \rho_i i_{t-1} + (1 - \rho_i) \left(\bar{i} + \gamma_\pi \pi_t + \gamma_x x_t \right) + v_t
\end{aligned}
$$

where $i_t^p \neq i_t$ is the interest rate relevant to the private spending decisions and $\mathrm{E}_t \pi_{t+}$ are expectations of inflation over the horizon corresponding to the maturity of loans

Fourth equation

The relation between the central bank interest rate and the private sector interest rate takes into account:

1. The default risk of private obligations
2. Their longer maturity

$$i_t^p = (1-\delta)\, i_t + \delta i_{t+}^e + \phi\, (R_t/A_t) + \omega_t$$

where:

- δ reflects maturity of the private sector assets
- R_t/A_t is the ratio of risky assets to total, $\phi' > 0$
- ω_t is a shock in the financial markets

Unconventional policies in the four-equation model

Forward guidance

- Communicating low interest rates in the future lowers i^e_{t+} and i^p_t

Quantitative easing

- Buying risky assets from commercial banks lowers R_t/A_t and i^p_t
- Buying longer maturity assets increases δ and (under forward guidance) lowers i^p_t

Drop in the natural real interest rate

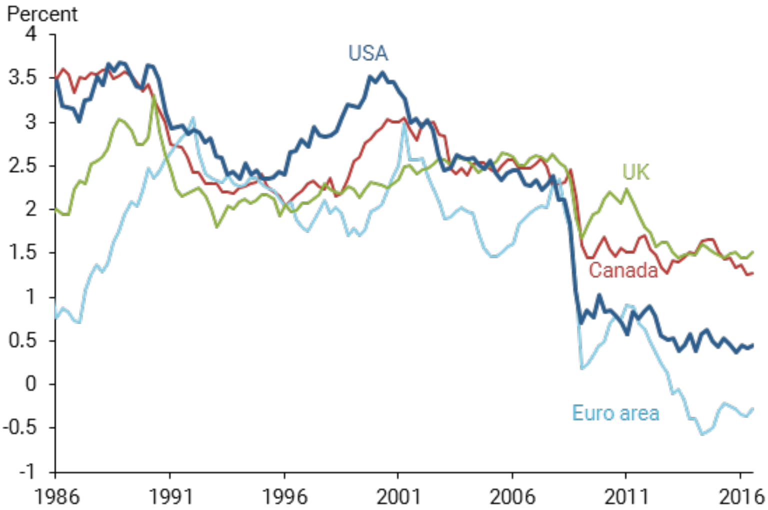
The ELB binds more often when the average nominal interest rates level is lower

Average nominal rate is the sum of inflation target and the natural real rate of interest

$$i = \pi^T + r^f$$
$$r^f = \rho + n + \sigma g$$

Due to demographics (increasing life expectancy: $\rho \downarrow$, declining fertility: $n \downarrow$) and lower rate of growth of productivity ($g \downarrow$), the natural real rate of interest has been falling in the advanced countries (Brand et al. 2018)

Drop in the natural real interest rate



Williams (2017)

Optimal inflation target

Without adjusting inflation targets advanced economies will experience ELB more often

- Blanchard et al. (2010) and Ball (2014): raise inflation target 4%: still low costs of inflation, ELB less often
- Coibon et al. (2012): even accounting for ELB costs the inflation target should be low
- Andrade et al. (2018): inflation target should be raised by 0.9 p.p. in response to decrease of r^f by 1 p.p.
- Ascari and Sbordone (2014): higher inflation leads to indeterminacy, caution advised

Question still remains open